SEISMIC SAFETY ELEMENT
FOR
PASO ROBLES

ENVICOM CORPORATION

February, 1975

RESOLUTION NO. 1927

A RESOLUTION OF THE CITY COUNCIL
OF THE CITY OF EL PASO DE ROBLES, STATE OF CALIFORNIA,
APPROVING AND ADOPTING THE SEISMIC SAFETY ELEMENT
OF THE GENERAL PLAN FOR THE CITY OF
EL PASO DE ROBLES

WHEREAS, the Planning Commission of the City of El Paso de Robles, did present to the City Council their recommendations and approval of a Seismic Safety Element of the General Plan for the City of El Paso de Robles; and

WHEREAS, pursuant to Government Code Section 65300 et seq., the said Council gave required notice and did hold public hearing on the 7th day of October, 1974, for the purpose of considering adopting of the Seismic Safety Element of the General Plan reports and maps, at which public hearing the Seismic Safety Element of the General Plan was explained and reported upon; and

WHEREAS, said Seismic Safety Element of the General Plan report and maps are necessary for the sound future of community development, the preservation of community and city-wide values and the promotion of the general health, safety, convenience and the welfare of the citizens of the City of El Paso de Robles; and

NOW, THEREFORE, BE IT RESOLVED THAT:

1. The City Council does hereby approve and adopt the Seismic Safety Element of the General Plan for the City of El Paso de Robles, dated February 24, 1975.

2. The City Clerk endorse and file a copy of report and maps, attesting to this Council's adoption;

3. A certified copy of the said element of the General Plan, report and maps, together with a certified copy of this resolution, be delivered to the Planning Commission of the County of San Luis Obispo.

ADOPTED, SIGNED and APPROVED this 24th day of February, 1975.

Barney Schwartz

BARNEY SCHWARTZ, MAYOR

ATTEST:

Donald B. Keefer

DONALD B. KEEFER, CITY CLERK

STATE OF CALIFORNIA)
COUNTY OF SAN LUIS OBISPO (SS.
CITY OF EL PASO DE ROBLES)

I, DONALD B. KEEFER, City Clerk of the City of El Paso de Robles, California, do hereby certify that the foregoing Resolution No. 1927 was duly and regularly adopted, passed, and approved by the City Council of the City of El Paso de Robles, California, at a regular meeting of said City Council held at the regular meeting place thereof, on the 24th day of February, 1975, by the following vote:

AYES: Councilmen Barnhart, Hanson, Stockdale and Schwartz

NOES: None

ABSENT: Councilman Minshull

I further certify that the City Council and the City Planning Commission gave required notice and did hold public hearings for the purpose of considering adoption of the Seismic Safety Element and that a record of said actions and hearings are contained in the official records of this City.

Dated this 24th day of February, 1975.

Donald B Keefer

City Clerk and Ex-Officio Clerk of the
City Council, City of El Paso de Robles,
State of California

POLICY SECTION

CONTENTS

I. INTRODUCTION

A. Seismic Hazard Recognition

The California State Legislature through requirements of the Seismic Safety Element has placed specific responsibilities on local government for identification and evaluation of seismic hazards and the formation of programs and regulations to reduce risk. Specific authority is derived from Government Code Section 65302 (f) which requires a seismic safety element of all city and county general plans, as follows:

> A seismic safety element consisting of an identification and appraisal of seismic hazards such as susceptibility to surface ruptures from faulting, to ground shaking, to ground failures, or to the effects of seismically induced waves such as tsunamis and seiches.
>
> The seismic safety element shall also include an appraisal of mudslides, landslides, and slope stability as necessary geologic hazards that must be considered simultaneously with other hazards such as possible surface ruptures from faulting, ground shaking, ground failure, and seismically induced waves.

The effect of this section is to require cities and counties to take seismic hazards into account in their planning programs. The basic objective is to reduce loss of life, injuries, damage to property, and economic and social dislocations resulting from future earthquakes.

The catalyst for this action stemmed largely from the February 9, 1971 earthquake. Recent conclusions from the Urban Geology Master Plan prepared by the California Division of Mines and Geology have also added impetus.

B. Purpose

1. To fulfill the requirement of State Planning Law (Section 65302-F Government Code) which states that a Seismic Safety Element is a mandated part of the General Plan required by each city and county in the State of California.

2. To meet contractual obligations entered into with the City of Paso Robles on October 4, 1973.

3. To assist in allocation of public resources in Paso Robles to develop information regarding seismic hazards and thereby develop a systematic approach to protect public health, safety and welfare from such hazards. Such information and protection devices are designed for further judicious growth and land use policies in conjunction with previously established city policies contained within the general plan.

C. Approach

This study is an extension and refinement of the larger San Luis Obispo Seismic Safety Element Study. The "Technical Report from the County study is to be considered an integral part of this report as the intent under which this study was undertaken is that Paso Robles will "adopt" as a part of their full Seismic Safety Element the County "Technical Report".

Through the provisions made in the contract with Paso Robles and as a basic philosophy in the conceptual discussions preliminary to its development, the Seismic Safety Element has been completed in two component report sections. The first concerns present and future implications to city policy while the second section addresses the refined technical research, analysis and findings from the County Technical Report. This section is not intended, however, to supersede the more indepth regional County study. Rather, it is a technical summary of the technical conditions affecting Paso Robles expansioned in the critical areas.

The basic philosophy under which this report has been prepared is that the intent of the Seismic Safety Element is to plan and prepare for the future based upon what we know today, rather than waiting until we know all that we would like to know.

D. Goals

Goals for Seismic Safety Element Study are a direct statement of community-wide aspirations. The goals presented below are considered to be at least the minimum requirement for a safer environment for the citizens of Paso Robles.

Allocation of resources twoard achievement of these goals will be a continuing consideration of decision makers over a long period of time. The achievement of these goals can be met in numerous ways, such as provision of adequate medical facilities, proper

disaster planning; carrying out of programs that are suggested in this report, and informing the citizenry and government employees of their obligations in time of emergency - of any kind. Should a severe disaster ever occur in Paso Robles it will be up to the citizenry to make many of the decisions necessary for the saving of life and property. Government can help - but it cannot do so without the consent and assistance of its citizens, and it is unreasonable to expect that government can do the job alone.

General goals under which this study was undertaken are:

1. Prevention of serious injury and loss of life

Loss of life and prevention of serious injury is a primary responsibility of local government and should be given highest priority in any seismic safety program.

2. Prevention of serious structural damage to critical facilities and structures where large numbers of people are apt to congregate at one time

Hospitals, communication facilities, public facilities, and other critical facilities should be designed to function after an earthquake.

3. Insuring the continuity of vital services and functions

This goal is most important in any disaster. It is one of the most important functions of government simply because there is unlikely to be any other organized source of leadership in a major disaster.

4. Education of the community

This goal is a necessary ingredient to the success of any planning effort. It is a role to be played by school districts, public agencies, business firms, and other civic minded individuals who have an interest in the safety programs of their communities.

E. Technical Conclusions

The policy section of the Seismic Safety Element is intended to reflect those important conclusions or findings from the technical analysis that may require direct response by city government. The range of responses may vary from simple acknowledgement to a complete change in a city code or ordinance.

Major conclusions from the technical section are as follows:

1. The City of Paso Robles, as is the State of California, is located in a seismically active area.

2. The states of activity of the major faults affecting Paso Robles have been evaluated using available detailed mapping supplemented by local field examinations and aerial photo study. The evaluation has been made in the context of definitions and procedures established for the Alquist-Priolo Act.

2. a) The San Andreas fault is active.

   b) The Nacimiento fault is seismically active. Data is inadequate to determine the potential for future ground rupture.

   c) The Rinconada fault is seismically active, but probably not the site of ground rupture in the near future.

   d) The Offshore fault is seismically active, but available marine geophysical data indicate future surface rupture is very improbable.

   e) The San Juan, La Panza, East Huasna, West Huasna, Edna, Indian Knob, San Miguelito, and Edna extended (?) faults are probably inactive.

3. No active faults are known to be present within or in the near vicinity of Paso Robles.

4. Surface rupture resulting from fault movement is not considered a significant problem within the city.

5. The City of Paso Robles is located in zone 2 (Plate I; and Plates 1A and 2A from County Technical Report) based upon analysis for the County Seismic Safety Element.

6. The primary source of ground shaking in Paso Robles should be the San Andreas fault.

7. The Nacimiento fault is considered a secondary source of strong ground shaking, but would have negligible effect on Paso Robles.

8. Shaking from earthquakes expected on the Rinconada and Offshore faults would not significantly override the severity of shaking expected from the San Andreas fault in the Paso Robles area.

9. Recent sediments in the Salinas River should be considered as potentially subject to liquefaction. The following is a generalized guide to liquefaction potential intended for use by soils engineers.

Material	Liquefaction Potential	Units on Plate I
Rock	Very low	P/T
Terrace deposits, etc.	Low to moderate	Q_1/Q_2
Recent alluvium	Moderate to High	R

10. The potential for landslides is considered to be negligible in rocks that underlie most of the city and the surrounding hills.

F. Risk

The CIR Guidelines separate risk into three distinct categories:

1. Acceptable Risk — The level of risk below which no specific action by government is deemed to be necessary.

2. Unacceptable Risk — The level of risk above which specific action by government is deemed to be necessary to protect life and property.

3. Avoidable Risk – risk not necessary to take because individual or public goals can be achieved at the same, or less, total "cost" by other means without taking the risk.

Appropriate risk should be determined with maximum citizen input. In making this determination, the appropriate planning response to a potential hazard involves a judgement, either explicit or implicit, of the risk that is acceptable. There is no such thing as a perfectly hazard-free environment. Natural and man-made hazards of some kind and degree are always present. However, efforts can be productively undertaken to try to mitigate the consequences of known hazards.

In the context of the Seismic Safety Element, the problem of risk is one of public policy and the appropriate allocation of public resources to mitigate hazards. The planner's responsibility is to provide a framework in which a community-wide, as opposed to an individual, response to the question can be meaningful. The first of several essential steps is the recognition of the presence of a hazard.

Once a problem has been recognized, considerable effort is required to evaluate its likely severity, frequency, and the characteristics of the area involved. This step should take into account the benefit/cost ratio of reducing hazard, acknowledging the intangibles involved, and comparing it with that of other projects. The factors of voluntary and involuntary exposure to risk must be considered in reaching a decision.

The choice of a particular earthquake, which protection is to be provided, involves a determination of acceptable risk. In general, the risk of occurrence decreases as the magnitude of the potential earthquake increases. Since the cost of providing protection increases as the magnitude of the "design earthquake" is increased, there is a point at which the cost of providing protection becomes prohibitive when considered in the light of the cost involved. Since it is the public that both receives and eventually pays for the protection, the choice of the level at which a risk becomes "acceptable" is a matter of public involvement with the determination being made by their elected representatives.

Qualification of the above foregoing "risk" definitions can be expressed in terms of a magnitude and a recurrence interval for a specific fault system. In Paso Robles, as indicated earlier, we are primarily concerned with the San Andreas fault system. From

analysis derived in the counties Technical Report and expanded in the technical section of this report, we recommend the following criteria be utilized as a basis for determining acceptable risk in Paso Robles.

Type of Facility	Fault System	Magnitude (Richter)
Normal (Residences, commercial, light manufacturing, etc.)	San Andreas	8.0+
Critical (hospitals, communication centers, public buildings, etc.)	San Andreas	8.0+

Response spectra (zones 2d and 2c) for the above fault have been included in the technical section of this report (Figures 1 & 2). (These response spectra should be analyzed by a structural engineer (Building and Safety Dept.) to determine the appropriate modification, if any, to the Paso Robles' Uniform Building Code.

It should be stressed, however, that this represents only a recommendation of acceptable risk and the public must ultimately decide on the level of risk they deem acceptable. Further, the public must also decide upon the types of land use that would fall under the facility classifications "normal" and "critical."

The following taxonomy of Critical Facilities is intended for use as a guide in evaluating the importance of each facility relative to overall public safety.

TAXONOMY OF CRITICAL FACILITIES

Facility	Potential Effect on Loss of Life	Required for Community Functioning
Dams	X	
Electrical Sub-stations		X
Schools/Colleges	X	
Fire Stations		X
Railroad Lines		X
Aqueducts	X	
County Buildings	X	
City Buildings	X	
Hospitals	X	X
Sewage Treatment Plants		X
Water Works		X
Radio Stations		X
Television Stations		X
Microwave Stations		X
Highway Patrol Offices		X
Major Highways/Bridges	X	X
Highway Tunnels	X	X

II. METHODOLOGY

The methodology under which this Seismic Safety Element Study has been undertaken places emphasis on those particular hazards that cannot be evaluated on a site-basis, or which can more efficiently be evaluated on a regional basis. Those hazards that can be effectively evaluated as a part of individual site investigations are treated in a general manner with the intent that the results be used to facilitate the administration of public safety. The relationship and attendant responsibilities between this concept and the evaluation of specific seismic/geologic hazards is as follows:

DISTRIBUTION OF RESPONSIBILITY FOR
EVALUATION OF SEISMIC/GEOLOGIC HAZARDS

Hazard	Responsible Sector	
	Public	Private
1. Fault rupture:		
a. Evaluation of fault	XXX	
b. Location at site		XX
2. Earthquake shaking:		
a. Sources of shaking	XXX	
b. General levels of shaking	XX	X
c. Effects on site		XX
3. Tsunami and seiche:		
a. Risk of occurrence	XXX	
b. Effects on site		XX
4. Dam failure:		
a. Risk of occurrence	XXX	
b. Effects of site		XX
5. Landslide:		
a. Regional evaluation	XX	X
b. Effects on site		XX
6. Liquefaction, settlement, & subsidence:		
a. Regional evaluation	XX(1)	
b. Effects on site		XX

(1) Evaluation requires determination of expected shaking.

The primary responsibility for evaluation of each aspect of a hazard is shown by an "XX", and by a "XXX" if a determination of acceptable risk is involved. Those aspects for which either sector may commonly have a secondary responsibility are indicated by an "X". The intent is to show the distribution of responsibility for evaluation of a hazard; the overall regulatory responsibility of government is not included.

The products developed in this study, as documented in the Technical Section, are primarily displayed on Plate I. They include seismic zones and secondary hazard areas.

A. Seismic Zones

The derivation of the twenty seismic zones for the entire County has been documented in the Technical Section. They are expressive of the level of groundmotion that can reasonably be anticipated from earthquakes on the principal fault systems affecting San Luis Obispo County. The characteristics of each seismic zone are represented by response spectra which translate groundmotion into displacement (inches); velocity (inches per second); and acceleration (inches per second per second expressed as a percent of the acceleration of gravity). These three factors which are derived from mathematical analysis are essentially the descriptors of each seismic zone.

In discussing the major groupings of the seismic zones the following general statements can be made:

1. The seismic zones have been derived from two basic sets of criteria, (1) distance from the source of an earthquake; and (2) geographic differentation of soil and bedrock conditions.

2. The seismic zone analysis for Paso Robles is based upon the San Andreas fault as the principal source of strong groundshaking.

3. Soil and bedrock conditions within this seismic zone have further been differentiated into the following generalized categories.

    c) Tertiary (pre-Pliocene) rocks

    d) Paso Robles formation

    e) Recent (Holocene) alluvium

B. Secondary Hazards

The evaluation of earthquake-related geologic hazards, such as landslides, settlement, liquefaction, etc., has been based on research and analysis of available maps and reports, study of aerial photographs of the area and some original geologic field work.

No areas of abnormally high risk due to secondary seismic/geologic hazards have been identified within the City limits of Paso Robles. The recent sediments of the Salinas River should be considered as potentially subject to liquefaction, but the risk from flooding in these areas exceeds that from liquefaction. The potential for landslides is negligible in the terrace deposits that underlie most of the City, and is also low in the hills that flank the valley.

In the context of this study the evaluation of secondary hazards, has been primarily aimed at identifying those hazards in which particular public attention should be focused prior to urbanization. This would principally involve those areas identified as susceptible to liquefaction and those areas having a moderate to high ground shaking classification.

III. SEISMIC SAFETY

A. Reducing Seismic Hazards

Two basic concepts should be considered in the upgrading and enforcing of building codes involving seismic risk. First, the primary role of government as related to seismic hazard is protection against loss of life or serious injury of its citizens, to implement this concern, it should adopt and enforce a code for the design and construction of new structures that will protect them, at an acceptable level of risk, against death or serious injury. It can be said that a structure which is not a critical facility (critical facilities are a separate issue) has performed well in an earthquake if no one is killed or seriously injured. The structure may be so damaged that it is a total loss to the owner, but it is a success from the standpoint of public safety if there are no serious injuries. In this concept, the role of government is limited to providing for public safety. Any additional costs required to protect the owner's investment would be at his discretion.

An alternative concept is suggested by events following the San Fernando earthquake in which certain governmental agencies provided funds for repair of damaged structures. In many cases, it is not necessary to repay a part of these funds, and the public as a whole accepted at least a part of the cost of repairing structures that were underdesigned for the area in which they were built. If the public does not wish to accept this responsibility, it could require that structures be designed to a level that would include protection against significant damage on the assumption that if they do not then they may have to pay the cost of repairing structures built in more hazardous areas.

The second basic concept is that certain critical facilities such as hospitals, fire and police stations, and communications centers will be required to function at peak efficiency in the hours immediately following a damaging earthquake. The level of protection desirable for a home or an office building may not be adequate for the structures in which these necessary services are housed.

During the hours immediately following the San Fernando earthquake most of the hospitals in the immediate area could not function because of damage, communication facilities at critical locations were not operative, and fire, police and ambulance service were severely restricted. This experience emphasized the need for a greater level of protection for facilities deemed to be critical due to a need to function in the hours immediately following a damaging earthquake

(e.g. hospitals and communication facilities), or because of an overall requirement that the facility continue to operate (e.g. important governmental buildings).

Increased protection for critical facilities can be applied in two ways. One way is to require that the structure be designed for an earthquake with a lower risk of occurrence. That is critical facilities could be designed to withstand the shaking expected from the "500 year" or "1000 year earthquake" while facilities designed for normal occupancy could have lesser requirements.

A second approach is related to "design level", an issue discussed previously. Buildings such as hospitals must not only remain intact but must also continue to function in a manner such that potential victims of an earthquake can be treated. This not only requires a stronger building, but also greater attention to non-structural items such as elevators, lighting fixtures, the stability of storage cabinets, etc.

Increased protection for critical facilities is a matter of public policy requiring public involvement at the decision stage and implementation in codes and ordinances by the elected representatives of the people. Public schools and hospitals are reviewed by the State Office of Architecture and Construction, but design criteria for other facilities are determined by local jurisdictions.

Working under the seismic parameters as presented in the Technical Section, a systematic inspection and structural analysis of existing structures in Paso Robles should be undertaken. Such a program should be under the direction of the City's Department of Building and Safety. The most important existing structures are, of course, critical facilities and those designated as public buildings. It is with these buildings that the structural evaluation processes should begin.

For existing structures that are non-critical in nature the following table (abridged from Pacific Fire Rating Bureau) shows relative damagability of varying structural types. This table can be used as a general indicator in older construction to establish a priority ranking for evaluation of non-critical structures. As an example, buildings with a high susceptability to damage rating (five or over) should be selected for structural inspection before those with low ratings.

TABLE A
HAZARD COMPARISON OF NON-EARTHQUAKE-RESISTIVE BUILDINGS

Simplified Description of Structural Type	Relative Damagability (in order of increasing susceptibility to damage)
Small wood-frame structures, i.e. dwellings not over 3,000 sq. ft. and not over 3 stories	1
Single or multistory steel-frame buildings with concrete exterior walls, concrete floors, and concrete roof. Moderate wall openings	1.5
Single or multistory reinforced-concrete buildings with concrete exterior walls, concrete walls, and concrete roof. Moderate wall openings	2
Large area wood-frame buildings and other wood frame buildings	3 to 4
Single or multistory steel-frame buildings with unreinforced masonry exterior wall panels; concrete floors and concrete roof	4
Single or multistory reinforced-concrete frame buildings with unreinforced masonry exterior wall panels, concrete floors and concrete roof	5
Reinforced concrete bearing walls with supported floors and roof of any material (usually wood)	5
Buildings with unreinforced brick masonry having sand-line mortar; and with supported floors and roof of any material (usually wood)	7 up
Bearing walls of unreinforced adobe, unreinforced hollow concrete block, or unreinforced hollow clay tile	Collapse hazard in moderate shocks

This table is intended for buildings not containing earthquake bracing, and in general, is applicable to most older construction. Unfavorable foundation conditions and/or dangerous roof tanks can increase the earthquake hazard greatly.

Critical facilities or public structures shown to be of inadequate construction should be noted and scheduled for demolition or reinforcement on a priority basis. If it is not economically feasible to provide an adequate level of protection by strengthening a structure, a lower level of occupancy may be desirable. If many high-risk structures are located in one area, redevelopment may be a solution.

Owners of existing commercial and residential buildings with obvious structural weaknesses should be notified of the conditions so appropriate repairs can be affected. In cases where the private owner is reluctant to take appropriate action, or where the costs of repairs are prohibitive, the local cities should at least take measures to protect the general public.

A program of this type is not without many social and economic problems and may require several years to complete. A reasonable time interval for completion of such a structural analysis program of existing buildings would be five years. As discussed earlier, earliest attention should be given to critical facilities. Their ability to function immediately after an earthquake will affect all of the citizens of Paso Robles, and they should receive the highest priority.

In considering future construction relative to secondary hazards, prime emphasis should be placed upon communicating to developers and builders the findings of this report. The problem of potential liquefaction (Plate I) should be handled on a site-by-site basis by a licensed Soils Engineer.

B. General Goals for Improving Seismic Safety

Two major goals should be attained along with implementation of the Seismic Safety Element; a Earthquake Disaster Plan should be formulated, and a Public Awareness Program initiated.

Earthquake Disaster Plan

An Earthquake Disaster Plan should be formulated which would enable the city to be self-sufficient in the weeks following a severe earthquake, such as a magnitude 8.5 event on the San Andreas fault.

An Earthquake Disaster Plan should provide for emergency medical facilities, temporary shelter, emergency communications equipment, and emergency water and food supplies. Since a large earthquake will severely affect many cities and hundreds of thousands of people, the

efforts of Federal and State emergency services will be severely overextended. It is advisable that Paso Robles be prepared to serve itself and maintain continued functioning of necessary services rather than expecting adequate aid from outside organizations.

Public Awareness

A program to increase public awareness of earthquake safety should be initiated. The program could be presented as a series of Community meetings or seminars. It should stress minimizing hazards in the home, and precautions to be taken after the occurrence of the earthquake. Appendix A (from California Geology, 1971) presents a comprehensive list of actions that an individual can take to minimize injury and loss in the event of an earthquake.

IV. RELATIONSHIPS TO OTHER GENERAL PLAN ELEMENTS

A. Safety

The Seismic Safety Element is a major input to the Safety Element which is defined in the Government Code Section 65302.1 as follows:

> "A safety element for the protection of the community from fires and geologic hazards including features necessary for such protection as evacuation routes, peak load water supply requirements, minimum road widths, clearances around structures, and geologic hazard mapping in areas of known geologic hazard."

Of particular importance to the Safety Element is the extent and severity of ground shaking and the areas designated as having ground-water and soil conditions conducive to potential liquefaction. Secondary hazards (landslides, etc.), as covered in the Technical Section are not considered a significant naturally occuring problem in and surrounding the City of Paso Robles.

Fire safety and inspection programs, water supply, clearances and evacuation routes are additional considerations which must be evaluated in completing this element.

B. Circulation/Transportation

The effect of the Seismic Safety Element upon surface sheet circulation and transportation is not considered significant. The principal reason is that the nature of seismic hazards in Paso Robles are not sufficiently narrow or restrictive as to meaningfully impact circulation corridors and transportation routes. It should be realized, however, that in the event of a "great earthquake" the major arteries for transportation may be heavily damaged or severed for days or weeks. This will put an additional load on major surface streets throughout the City of Paso Robles. For this reason a disaster plan for the City should focus on lesser used throughway streets.

C. Land Use

Based on the Technical Section, there are no areas within the City of Paso Robles in which a particular land use should be prohibited. Construction activity in the more critical seismic and secondary hazard zones would probably require additional capital costs to offset the

increased seismic forces, but no area should be termed "off-limits" for specialized land uses, including critical facilities.

The present distribution of land use, in general, will not be adversely effected by ground shaking; except in those areas underlain by recent alluvium. Those areas in which the potential for secondary hazards exist, however, should be treated on an individual site-basis with the Technical Section providing the background for identification of those "high" and "moderate" risk hazard areas.

The counties Technical Report and this report has dealt with the major faults. Other lessor faults do exist. These are far less important than any of the major faults examined. Most of these lesser faults are of short length and of little consequence beyond the immediate vicinity of the fault. As the location and dimensions of these faults become known from future detailed studies, new construction should not be placed immediately atop or astride the faults. It should be the responsibility of the Department of Building and Safety to establish a reasonable building set-back distance based upon future detailed studies.

D. Housing

Findings of the study indicate there should be no restrictions placed on the location or type of single-family housing within Paso Robles based on the response spectra in the Technical Section. The Seismic Safety Element's effect on housing in Paso Robles is primarily limited to replacement or strengthening of unsafe structures and the requirement of new construction to be in conformance with seismic modifications to the City building code.

Regardless of building height, the most critical zones will experience shaking. The less critical areas, in an 8.5 Richter earthquake on the San Andreas fault, will experience less shaking with lower frequency shock waves. The taller structures will; however, be more impacted than the lower storied structures.

The same provisions specified in the discussion on Land Use regarding construction on known faults should, of course, also apply to the Housing Element.

E. Open Space

The nature of seismic hazards (ground shaking) in Paso Robles is not sufficiently narrow or restrictive as to meaningfully designate areas to be considered for open space. Significant secondary hazards may exist in terms of liquefaction (Plate I) and some consideration of such hazards areas as open space may be justified.

V. POLICIES AND IMPLEMENTATION RECOMMENDATIONS

The State of California considers the threat of earthquake serious enough to require a Seismic Safety Element in the General Plan of all incorporated governmental bodies. At the same time, it should be realized that the threat of earthquake is not the same at all times or in all places. This Seismic Safety Element traces the impacts of a maximum probable earthquake from the San Andreas fault on Paso Robles. The proceeding discussions has indicated the City can initiate many actions to counter these anticipated impacts. The most important implications of seismic safety to the City of Paso Robles are in terms of building and disaster preparedness. The following represents a summation of the important study findings and is presented as Policy Recommendations for review and eventual adoption by the City Council.

A. Policy Recommendations

1. Adopt the Uniform Building Code, 1973 edition.

2. The building department should use as a guideline the seismic zones and attendant response spectra for modification of the City of Paso Robles building code to bring it into conformance with expected seismic conditions resulting from future earthquakes.

3. A program of building inspection should be initiated to identify all unreinforced masonry structures in the City that do not meet modern earthquake standards for construction and conform to design criteria of the modified city building code.

4. The Building Department should establish and implement a program for the orderly restoration and/or elimination of hazardous old buildings.

5. The Technical Section of this Report should be made available to developers for review and use when proposing new land development projects.

6. A building strong-motion instrumentation program should be instituted for buildings four (4) stories or more in height.

7. A review committee should be established by the City Council to consider the desirability of initiating abatement proceedings against unreinforced masonry structures found to be unsafe. Special consideration to Heritage structures.

8. Emergency communication centers, fire stations, and other emergency service facilities should be examined as to their earthquake resistant capacities. If found below acceptable standards, a program to mitigate potential hazards should be immediately established.

9. All critical facilities constructed prior to 1948 should be reviewed by a structural engineer for potential hazards. Since many of these structures have regional impact, the source of funding for the inspection program ought to be at the regional level.

10. New construction directly astride or across the San Andreas fault, or fault zone should be prohibited. Non-structural land uses; however, should not be prohibited.

11. Community programs that train volunteers to assist police, fire, and civil defense personnel how to perform effectively after an earthquake, should be supported.

12. Section 65402 of the Government Code relating to subdivisions and zoning ordinances requires that all developments be submitted for governmental review. Paso Robles should enforce this provision taking into account recommendations from the Seismic Safety Element report.

13. The City should develop an information release program to familiarize the citizens of the region with the Seismic Safety Element. School Districts and agencies related to aged, handicapped and seismically susceptible industries should be encouraged to develop education programs relative to seismic awareness.

14. Chapter 70 of the Uniform Building Code should be adopted and enforced. To insure this, Paso Robles should retain on a full or part-time basis, a qualified engineering geologist to review reports.

15. Upon adoption of this Element, the City should establish a seismic safety review committee to oversee the implementation of this element. This committee should be composed of the Director of Building and Safety, the Director of Public Works, the Planning Director, and at least one representative from police and fire protection service agencies.

16. Establish a priority system of roads, services and other vital needs in the event of an earthquake disaster.

17. Emergency Services Program

    a. Implement emergency service requirements of Seismic Element in a declared disaster and coordinate activities of police, fire, civil defense and volunteer activities.

    b. Prepare geologic disaster information release programs for use in emergencies.

18. State, Federal, and other governmental agencies should be encouraged to intensify research on seismic and other geologic hazards and the poor circulation across the Salinas should be corrected in the Paso Robles area.

19. The Seismic Safety Element should be reviewed by the City Planning Department annually and should be comprehensively revised every five years or whenever substantially new scientific evidence becomes available.

TECHNICAL SECTION

CONTENTS

LIST OF ILLUSTRATIONS

I. SUMMARY OF TECHNICAL ANALYSIS

A. Geologic and Seismic Setting

The City of Paso Robles is located on the west and east banks of the Salinas River. The main part of the City along U.S. Highway 101 is underlain by late Pleistocene terrace sands and gravels, while the low hills along the western edge of the City and the rolling hills on the east bank of the River are underlain by Pliocene Paso Robles Formation (Plate I). Monterey Shale crops out just west of the City near Terrace Hill Park.

The Jolon fault and the Rinconada fault transect the southwestern part of the City, but converge to form one fault or fault zone near Mountain Springs Road (Plate I). To the northwest of Mountain Springs road, the location of the Jolon fault is based on mapping by Durham (Burch and Durham, 1970). Its projection through the City and on the east side of the River is based on the alignment of warm, sulfur springs shown on Plate I. The alignment of the Rinconada fault is based on regional mapping to the south (Burch and Durham, 1970); an exposure of the fault, or at least one branch of it, in the cuts for the railroad about 2200 feet south of the city limits; and on the alignment of topographic features in the low hills near the west edge of the city.

B. Activity of Faults

Regional data bearing on the activity of the Rinconada and Jolon faults is summarized in the technical section of the Seismic Safety Element for the County of San Luis Obispo (Envicom, 1974). These data indicate that these faults may have been active as recently as early Pleistocene in the vicinity of Paso Robles, and as recently as late Pleistocene near Santa Margarita. However, there is no evidence that either fault has moved during the Holocene (last 11,000 years approximately), and, therefore, that either should be considered as "active" within the policies and definitions established for evaluation of geologic hazard zones as defined by the Alquist-Priolo Act.

Local data bearing on this determination include: 1) the presence of deposits of the upper terrace level overlying the Rinconada fault (or at least one branch of it) and apparently uncut by it where it crosses the railroad south of the City; and 2) the absence of any lineation within the terrace deposits overlying the Jolon fault as observed on aerial photographs (AXH-5CC-70, 71, 154, 155, Feb. 25, 1963) of the area. The Jolon fault

apparently controls the approximate location of the hot, sulfur springs in the southern part of the City and to the southeast, but this control could be effective without the fault cutting the late Pleistocene terrace deposits.

C. Earthquake Shaking

While the Rinconada and Jolon faults are not considered "active" with respect to the fault rupture (Envicom, 1974), they may be the site of moderate seismic activity. Analysis of the historical record of instrumental epicenters in the area suggests that an earthquake of Richter magnitude 5.5 could be expected at 400 to 500-year intervals on these faults. However, such an event would not be expected to rupture the ground surface, but would more likely be confined to a depth of approximately 5 to 8 miles. At this depth, ground shaking even in the immediate area of the epicenter should not exceed that from the expected magnitude 8.0 to 8.5 earthquake on the San Andreas fault. For this earthquake, Paso Robles is located primarily in Zone 2d with the alluvium of the recent river channel in Zone 2e. Areas to the west of the City underlain by Monterey Shale are in Zone 2c. The response spectra for Zones 2c and 2d are shown in Figures 1 and 2, and the general characteristics of shaking are shown in Table 1. Modifications to be applied to the spectra depending on the thickness of recent alluvium (Zone 2e) are given in Table 2.

TABLE 1
GENERALIZED GROUND-SHAKING CHARACTERISTICS FOR ZONES AT AND NEAR PASO ROBLES BASED ON A MAGNITUDE 8.5 EARTHQUAKE ON THE SAN ANDREAS FAULT

	Zone 2d	Zone 2c
Maximum ground acceleration (gravity)	0.27	0.15
Predominant period (seconds)	0.3-0.5	0.4-0.6
Duration of strong shaking (seconds)	40-50	30-40
Spectra	Fig. 1	Fig. 2

Ground shaking from earthquakes expected on the Nacimiento fault should be less severe than that expected from the San Andreas fault discussed above.

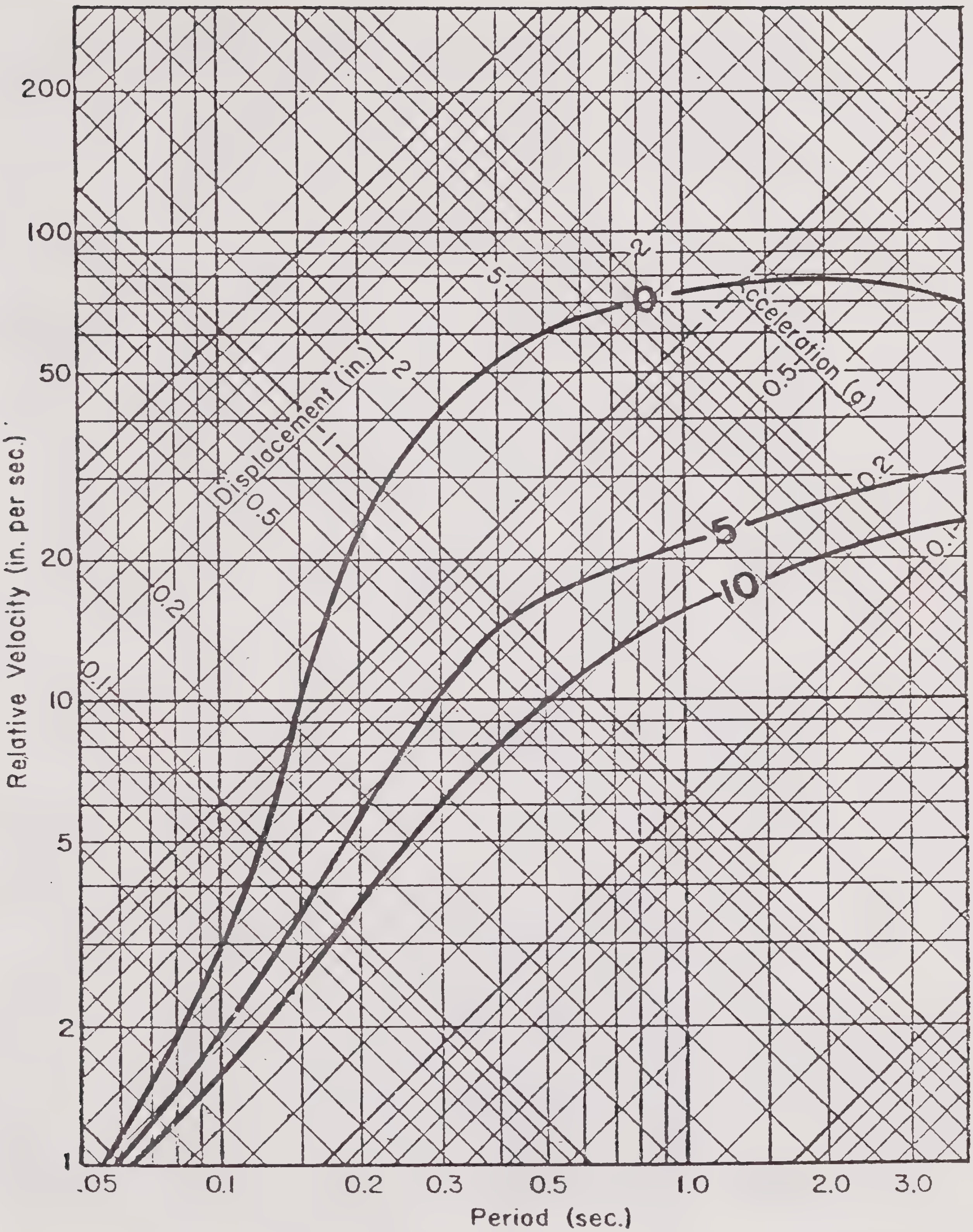

Figure 1. Response spectra for magnitude 8.5 earthquake on San Andreas fault for Zone 2d and 0, 5, and 10% critical damping.

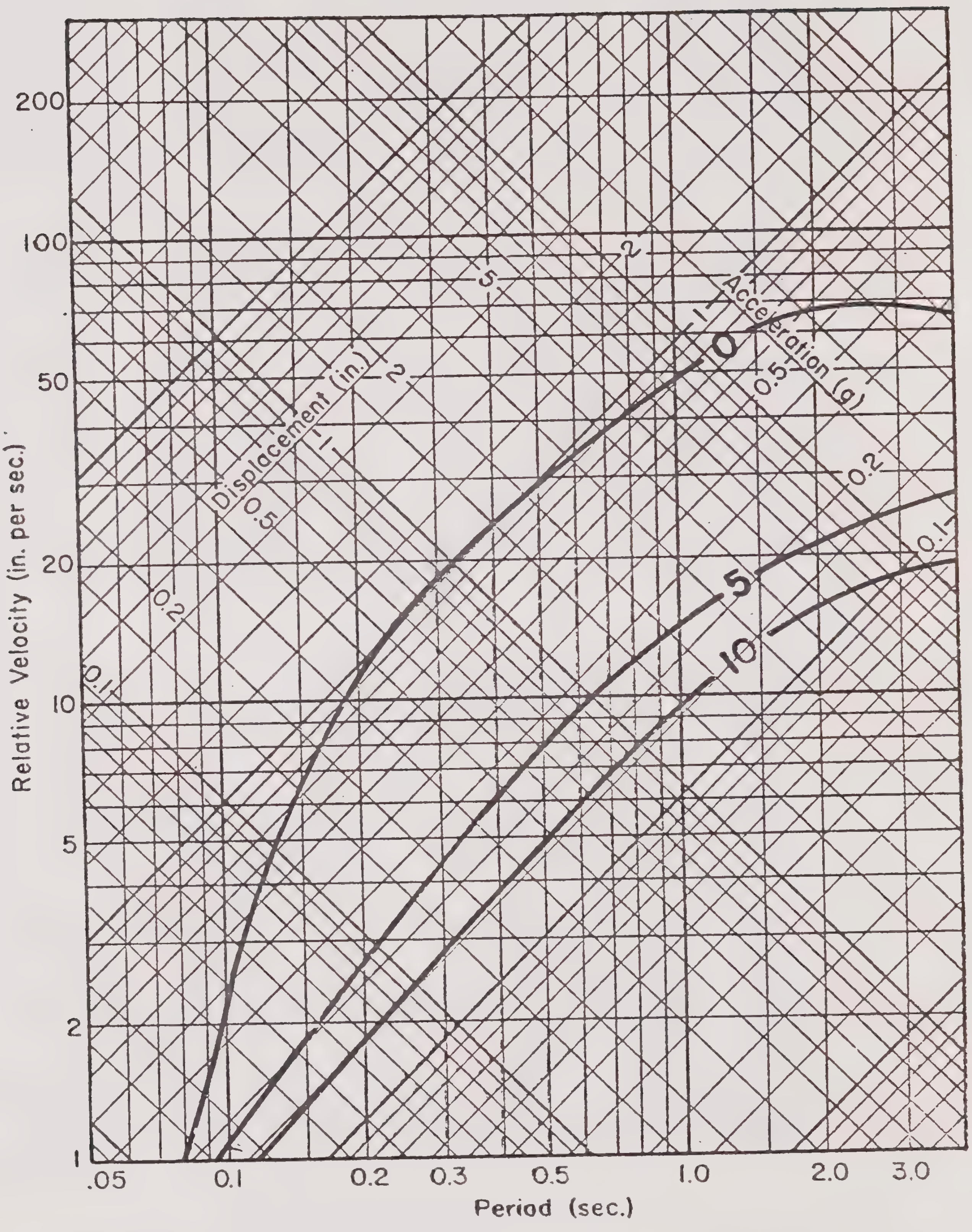

Figure 2. Response spectra for magnitude 8.5 earthquake on San Andreas fault for Zone 2c and 0, 5, and 10% critical damping.

TABLE 2
AMPLIFICATION CHARACTERISTICS FOR SITES ON
RECENT ALLUVIUM AND THIN PLEISTOCENE DEPOSITS

<table>
<tr><td colspan="4">AMPLIFICATION FACTORS:</td></tr>
<tr><td colspan="2">Condition</td><td colspan="2">Amplification Factor</td></tr>
<tr><td>e/c</td><td>Recent alluvium over Tertiary</td><td colspan="2">2.5</td></tr>
<tr><td>e/d</td><td>Recent alluvium over marine Pliocene or firm Pleistocene</td><td colspan="2">1.5-2.5</td></tr>
<tr><td colspan="4">PERIOD OF AMPLIFICATION:</td></tr>
<tr><td colspan="2">Thickness (feet) of</td><td rowspan="2" colspan="2">Period (Seconds)</td></tr>
<tr><td>Recent Alluvium</td><td>Pleistocene</td></tr>
<tr><td>15</td><td>30</td><td colspan="2">0.0.1</td></tr>
<tr><td>40</td><td>100</td><td colspan="2">0-0.2</td></tr>
<tr><td>70</td><td>100</td><td colspan="2">0.1-0.3</td></tr>
<tr><td>150</td><td>-</td><td colspan="2">0.2-0.5</td></tr>
</table>

D. Secondary Hazards

No areas of abnormally high risk due to secondary seismic/geologic hazards have been identified within the city limits of Paso Robles. The recent sediments of the Salinas River should be considered as potentially subject to liquefaction, but the risk from flooding in these areas exceeds that from liquefaction. The terrace deposits on which the major part of the City is built can be considered as having a low to moderate liquefaction potential in the presence of shallow groundwater (less than 30 feet). This potential should be considered in future investigations by the soils engineer utilizing the expected ground shaking as described herein and the detailed soils and groundwater data available from the site investigation. The relationships between these parameters and the potential for liquefaction are shown on Figure 3.

The potential for landslides is negligible in the terrace deposits that underlie most of the City, and is low in the hills that flank the valley because of the granular nature of the rocks and the generally poor

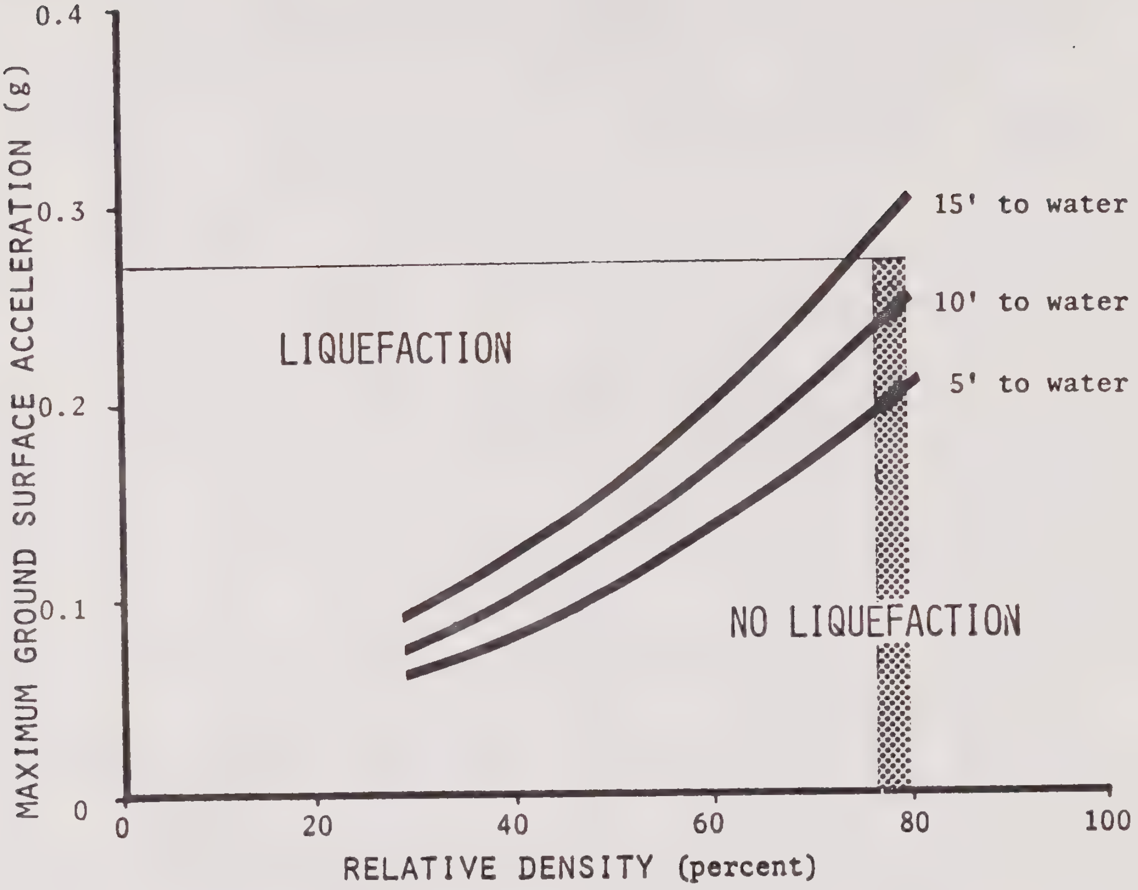

Figure 3. Liquefaction potential for an earthquake of magnitude 8.0 to 8.5.

development of bedding that could act as a surface on which failure would likely occur. However, anomalous conditions should be expected along the faults in the southwestern part of the City, and engineering geologic and soils engineering investigations should be undertaken in this area prior to any significant grading for construction of housing, roads, etc.

Note to appear on all seismic safety maps:

> "This General Plan map is intended to be used as a general guide for land use planning and the administration of public safety. Areas indicated as seismic hazards, faults, and landslide risk are not precise and may require detailed study to determine actual risk and/or mitigating requirements."

APPENDIX A

Earthquake Safety Procedures

EARTHQUAKE SAFETY PROCEDURES

Before an Earthquake

1. Potential earthquake hazards in the home should be removed or corrected. Top-heavy objects and furniture, such as bookcases and storage cabinets, should be fastened to the wall and the largest and heaviest objects placed on lower shelves. Water heaters and other appliances should be firmly bolted down, and flexible connections should be used whenever possible.

2. Supplies of food and water, flashlight, a first-aid kit, and a battery-powered radio should be set aside for use in emergencies. Of course, this is advisable for other types of emergencies, as well as for earthquakes.

3. One or more members of the family should have a knowledge of first aid procedures because medical facilities nearly always are overloaded during an emergency or disaster, or may themselves be damaged beyond use.

4. All responsible family members should know what to do to avoid injury and panic. They should know how to turn off the electricity, water, and gas; they should know the locations of the main switch and valves. This is particularly important for teenagers who are likely to be alone with smaller children.

5. It is most important for a resident of California to be aware that this is "earthquake country" and that earthquakes are most likely to occur again where they have occurred before. Building codes that require earthquake-resistant construction should be vigorously supported and, when enacted into law, should be rigorously enforced. If effective building codes and grading ordinances do not exist in your community, support their enactment.

During An Earthquake

1. The most important thing to do during an earthquake is to remain calm. If you can do so, you are less likely to be injured. If you are calm, those around you will have a greater tendency to stay calm, too. Make no moves or take no action without thinking about the possible consequences. Motion during an earthquake is not constant; commonly, there are a few seconds between tremors.

2. If you are inside a building, stand in a strong doorway or get under a desk, table, or bed. Watch for falling plaster, bricks, light fixtures, and other objects. Stay away from tall furniture, such as china cabinets, bookcases, and shelves. Stay away from windows, mirrors, and chimneys. In tall buildings, it is best to get under a desk if it is securely fastened to the floor, and to stay away from windows or glass partitions.

3. Do not rush outside. Stairways and exits may be broken or may become jammed with people. Power for elevators and escalators may have failed. Many of the 115 persons who perished in Long Beach and Compton in 1933 ran outside only to be killed by falling debris and collapsing chimneys. If you are in a crowded place such as a theater, athletic stadium, or store, do not rush for an exit because many others will do the same thing. If you must leave a building, choose your exit with care and, when going out, take care to avoid falling debris and collapsing walls or chimneys.

4. If you are outside when an earthquake strikes, try to stay away from high buildings, walls, power poles, lamp posts, or other structures that may fall. Falling or fallen electrical power lines must be avoided. If possible, go to an open area away from all hazards but do not run through the streets. If you are in an automobile, stop in the safest possible place, which, of course, would be an open area, and remain in the car.

After An Earthquake

1. After an earthquake, the most important thing to do is to check for injuries in your family and in the neighborhood. Seriously injured persons should not be moved unless they are in immediate danger of further injury. First aid should be administered, but only by someone who is qualified.

2. Check for fires and fire hazards. If damage has been severe, water lines to hydrants, telephone lines, and fire alarm systems may have been broken; contacting the fire department may be difficult. Some cities, such as San Francisco, have auxiliary water systems and large cisterns in addition to the regular system that supplies water to fire hydrants. Swimming pools, creeks, lakes, and fish ponds are possible emergency sources of water for fire fighting.

3. Utility lines to your house - gas, water, and electricity - and appliances should be checked for damage. If there are gas leaks, shut

off the main valve which is usually at the gas meter. Do not use matches, lighters, or open-flame appliances until you are sure there are no gas leaks. Do not use electrical switches or appliances if there are gas leaks, because they give off sparks which could ignite the gas. Shut off the electrical power if there is damage to the wiring; the main switch usually is in or next to the main fuse or circuit breaker box. Spilled flammable fluids, medicines, drugs, and other harmful substances should be cleaned up as soon as possible.

4. Water lines may be damaged to such an extent that the water may be off. Emergency drinking water can be obtained from water heaters, toilet tanks, canned fruits and vegetables, and melted ice cubes. Toilets should not be flushed until both the incoming water lines and outgoing sewerlines have been checked to see if they are open. If electrical power is off for any length of time, plan to use the foods in your refrigerator and freezer first before they are spoiled. Canned and dried foods should be saved until last.

5. There may be much shattered glass and other debris in the area, so it is advisable to wear shoes or boots and a hard hat if you own one. Broken glass may get into foods and drinks. Liquids can be either strained through a clean cloth such as a handkerchief or decanter. Fireplaces, portable stoves, or barbecues can be used for emergency cooking but the fireplace chimney should be carefully checked for cracks and other damages before being used. In checking the chimney for damage, it should be approached cautiously, because weakened chimneys may collapse with the slightest of aftershocks. Particular checks should be made of the roof line and in the attic because unnoticed damage can lead to a fire. Closets and other storage areas should be checked for objects that have been dislodged or have fallen, but the doors should be opened carefully because of objects that may have fallen against them.

6. Do not use the telephone unless there is a genuine emergency. Emergencies, and damage reports, alerts, and other information can be obtained by turning on your radio. Do not go sightseeing; keep the streets open for the passage of emergency vehicles and equipment. Do not speculate or repeat the speculations of others - this is how rumors start.

7. Stay away from beaches and other waterfront areas where seismic sea waves (tsunamis), sometimes called "tidal waves", could strike. Again, your radio is the best source of information concerning the likelihood that a seismic sea wave will occur. Also stay away from steep landslide-prone areas if possible, because aftershocks may trigger a

landslide or avalanche, especially if there has been a lot of rain and the ground is nearly saturated. Also stay away from earthquake-damaged structures. Additional earthquake shocks known as "aftershocks" normally occur after the main shock, sometimes over a period of several months. These are usually smaller than the main shock but they can cause damage, too, particularly to damaged and already weakened structures.

8. Parents should stay with young children who may suffer psychological trauma if parents are absent during the occurrence of aftershocks.

9. Cooperate with all public safety and relief organizations. Do not go into damaged areas unless authorized; you are subject to arrest if you get in the way of, or otherwise hinder, rescue operations. Martial law has been declared in a number of earthquake disasters. In the 1906 disaster in San Francisco, several looters were shot.

10. Send information about the earthquake to the Seismological Field Survey to help earth scientists understand earthquakes better.

APPENDIX B

General Characteristics of Earthquakes

A. GENERAL CHARACTERISTICS OF EARTHQUAKES

1. The Source of Earthquakes

Earth scientists are generally agreed that earthquakes originate as the result of an abrupt break or movement of the rock in the relatively brittle crust of the earth. The earthquake is the effect of the shock waves generated by the break, much the same as sound waves (a noise) are generated by breaking a brittle stick. If the area of the break is small and limited to the deeper part of the crust, the resulting earthquake will be small. However, if the break is large and extends to the surface, then the break can result in a major earthquake.

These breaks in the earth's crust are called faults. In California, faults are extremely common, and vary from the small breaks of an inch or less that can be seen in almost any road-cut, to the larger faults such as the San Andreas on which movement over many millions of years has amounted to hundreds of miles. In addition to the size of faults, their "age" is also important. Many large faults have not moved for millions of years; they are considered "dead" or "inactive". They were probably the source of great earthquakes millions of years ago, but are not considered dangerous today.

Since faults vary as to the likelihood of their being the source of an earthquake, considerable effort has, and is continuing to be expended by geologists and seismologists to determine and delineate the faults are classified generally as follows:

(1) An historically active fault is one which is known to have slipped during historical time, or one which is associated with an alignment of earthquake epicenters. In California this "historical time" span is limited to approximately 150 years.

(2) An active fault is one that has moved in the result geologic past, and that can be expected to move again in the foreseeable future. The "recent geologic past" is generally interpreted to include recent geologic time; a period of approximately 10,000 years. However, a precise definition of "active fault", such as is needed where the term is included in legal documents, is still a matter of considerable debate.

(3) A potentially active fault is one that lacks the criteria to be classified as active, but which must be considered suspect because of offset of Quanternary sediments (up to approximately 2 million years old) or the presence of scattered earthquake

epicenters. This classification, may be applied as much due to lack of definitive data as to the presence of data that definitely precludes recent movement.

2. Describing an Earthquake

Several terms are used to describe the location, "size", and effects of an earthquake. A clear understanding of the meaning of these terms and their limitations is essential to an understanding of the results of the investigation.

The location of an earthquake is generally given as the epicenter of the earthquake. This is a point on the earth's surface vertically above the hypocenter or focus of the quake. The latter is the point from which the shock waves first emanate. However, as discussed above earthquakes originate from faults. These are surfaces not points, so the hypocenter is only one point on the surface (or volume) that is the source of the earthquake.

Magnitude describes the size of the earthquake itself. Technically, it is defined as the logarithm of the maximum amplitude as recorded on a standard seismograph at 100 kilometers (62 miles) from the epicenter. The most important part of this definition is that it is a logarithmic scale (e.g. magnitude 5.0 to 6.0) represents an increase of 10 in the amplitude of the recorded wave. It should also be noted that the magnitude of an earthquake is determined at a considerable distance from the center of the earthquake, and that it is based on ground displacement rather than ground acceleration.

Intensity describes the degree of shaking in terms of the damage at a particular location. The scale used today is the Modified Mercalli Scale, and is composed of 12 categories (I to XII) of damage as described in Table 1. The Roman numerals are used to emphasize that the units in the scale are descrete categories rather than a continuous numerical sequence as is the magnitude scale. It is important to remember that intensity is a very general description of the effects of an earthquake, and depends not only on the size of the quake and the distance to its center but also on the quality of the construction that has been damaged and the nature of local ground conditions.

3. Occurrence and Recurrence of Earthquakes

Earthquakes have had in the past a certain occurence in space and time. These occurrences may or may not set certain patterns that can form the basis for predicting their occurrence in the future. When such

occurrences are analyzed in time, certain characteristics may statistically recur at definite intervals. If it can be shown that a particular magnitude earthquake recurs on a fault on the average of a certain number of years, this number can be said to be the recurrence interval for the magnitude. Of course, if the interval of time is set (e.g. a 100-year period), then earthquakes of a particular magnitude will recur a certain number of times in the specified period.

In California, as in most large areas, small earthquakes occur much more often than large earthquakes. Also, there is a fairly definite pattern in that the logarithm (base 10) of the number of events of a particular magnitude that have occurred in the past is approximately proportional to the magnitude of those events. This relationship appears to apply to larger areas such as California and western Nevada, some smaller areas such as the Los Angeles Basin, and to some faults such as the Newport-Inglewood. However, this relationship does not apply to all faults, and it should be applied to small areas, such as cities or individual sites, with great care.

B. ENGINEERING CHARACTERISTICS OF EARTHQUAKES

The data of seismologists and geologists are, in general, not applicable to the engineering design of earthquake-resistant structures. The seismograph, for example, is a very sensitive instrument designed only to record earthquakes at great distances. A level of shaking that would be meaningful to an engineer in designing a building would put most seismographs completely off-scale.

As a result, it has been necessary to design and install special instruments to record the strong motions of earthquakes that are of interest to the engineer in the design of earthquake-resistant structures The first such instruments, principally accelerographs and seismoscopes, were installed by the U.S. Coast and Geodetic Survey in the late 1920's and the 1933 Long Beach earthquake as the first real test of the system. The motions were apparently stronger than expected, and the accelerograph record from Long Beach itself has never been adequately deciphered. Since that time, the instrumentation and analytical techniques have been obtained of the more recent strong earthquakes.

The following sections are a brief introduction to the concepts, data and application of strong-motion records. The science is relatively young, and is growing in bursts that follow the recording of a damaging earthquake.

1. Acceleration, Velocity, and Displacement

The accelerograph is a short-period instrument (in contrast to the seismograph), and measures the acceleration of the ground or the structure on which it is mounted. Figure 1 shows the ground acceleration recorded just a few hundred feet from the fault during the 1966 Parkfield earthquake. The velocity and displacement curves have been derived from it by integration. It is a particularly good example of the relationships of these three parameters of motion because of the relatively "clean", single-displacement pulse that corresponds to two velocity peaks and four acceleration peaks. Figure 2 shows the more typically complex record of the San Fernando earthquake as recorded at Pacoima Dam. Neither of the two, however, are typical records in terms of accelerations recorded. The Pacoima record shows the largest acceleration recorded to date (1.25g), and the Parkfield record (0.5g) was the largest before the San Fernando earthquake.

It should also be noted that accelerographs normally record three components; two in the horizontal plane at right angles to each other, and one vertical. Only one component is shown in each of the two examples.

Maximum acceleration is one of the basic parameters describing ground shaking, and has been the one most often requested by agencies such as FHA in determining the earthquake hazard to residential structures. It is particularly important for "low-rise" construction (up to 3 to 5 stories) and other structures having natural periods in the range of 0.3 - 0.5 seconds or less.

2. Frequency Content — Fourier and Response Spectra

The frequency content of the ground motion is particularly important for the intermediate and higher structures. The problem can be compared to pushing a child in a swing. If the pushes are timed to coincide with the natural period of the swing, then each push makes the swing go higher. However, if the timing is not right, then most of the push is loss "fighting" the natural period of the swing. The situation is similar during earthquakes. Structures have certain periods of vibration. If the pulses of the earthquake match the natural period of the structure, even a moderate earthquake can cause damaging movement. However, if the match is poor, the movement and resulting damage will be much less.

Two methods are commonly used to analyze and display the frequency content of an earthquake. A Fourier analysis is a common mathematical method of deriving the significant frequency characteristics of a time-signal such as the record of an earthquake. The results of the analysis are an amplitude term and a phase term. The amplitude is normally plotted against the period for that amplitude to give a Fourier amplitude spectrum for the range of frequencies that are of interest. Since the mathematical procedure is basically an integration of acceleration with time, the Fourier amplitude has the units of velocity.

A response spectrum is derived by a similar mathematical process, but is slightly different in concept. It represents the maximum response of a series of oscillators, having particular periods and damping, when subjected to the shaking of the earthquake. The result is also expressed in terms of velocity with the particular nomenclature depending on the precise method used to derive the spectrum.

The Fourier spectrum can be generally described as the energy available to shake structures having various natural frequencies. The response spectrum gives the effect, in maximum velocity, of this available energy on simple structures having various frequencies and damping. At zero damping the two are very similar. Figure 3 shows a plot of both the Fourier spectrum and the response spectrum with zero damping for the Taft earthquake of 1952. Figure 4 shows the response spectrum for the Parkfield record (Figure 1) for several levels of damping.

3. Near-Surface Amplification

The shock waves of an earthquake radiate outward from the source (i. e. the slipped fault) through the deeper and relatively more dense parts of the earth's crust. In this medium, the waves travel at high velocity and with relatively low amplitude. However, as they approach the surface, the velocity of the medium decreases and may become quite variable if layers of different rock types are present. The overall effect is generally an amplification of the wave or of certain frequencies within the spectrum of the wave.

The most consistently applicable effect is the increase in wave amplitude that accompanies the decrease in velocity. This relationship can be compared to laws of mechanics that require the conservation of energy and momentum. In the case of earthquake waves, the energy of velocity is transferred to energy of wave amplitude when the velocity decreases.

APPENDIX C

Glossary of Terms

Active Fault — One that has moved in recent geologic time and which is likely to move again in the relatively near future. Definitions for planning purposes extend on the order of 10,000 years or more back and 100 years or more forward.

Alluvial — Pertaining to or composed of alluvium, or deposited by a stream or running water. (AGI, 1972)

Alluvium — A general term for clay, silt, sand, gravel or similar unconsolidated detrital material deposited during comparatively recent geologic time by a stream or other body of running water as a sorted or semisorted sediment in the bed of the stream or on its flood plain or delta, or as a cone or fan at the base of a mountain slope. (AGI, 1972)

Amplification — Elaboration; augmentation; addition (Webster). As used herein, near-surface amplification is the augmentation of wave amplitude resulting from the change in physical properties in near-surface layers (see Introduction).

Amplitude — The extent of the swing of a vibrating body on each side of the mean position. (Webster)

Block Glide — A translational landslide in which the slide mass remains essentially intact, moving outward and downward as a unit, most often along a pre-existing plane of weakness such as bedding, foliation, joints, faults, etc. (AGI, 1972)

Cohesion — Shear strength in a sediment not related to interparticle friction. (AGI, 1972)

Colluvium — (a) A general term applied to any loose, heterogenous, and incoherent mass of soil, material or rock fragments deposited chiefly by mass-wasting, usually at the base of a steep slope or cliff. (b) Alluvium deposited by unconcentrated surface runoff or sheet erosion, usually at the base of a slope. (AGI, 1972)

Compaction — Reduction in bulk volume or thickness of, or the pore space within, a body of fine-grained sediments in response to the increasing weight of overlying material that is continually being deposited, or to the pressure resulting from earth movements within the crust. It is expressed as a decrease in porosity brought about by a tighter packing of the sediment particles. (AGI, 1972)

Consolidated Material — Soil or rocks that have become firm as a result of compaction.

Damping — The resistance to vibration that causes a decay of motion with time or distance, e.g. the diminishing amplitude of an oscillation. (AGI, 1972)

Differential Settlement — Nonuniform settlement; the uneven lowering of different parts of an engineering structure, often resulting in damage to the structure. (AGI, 1972)

Displacement (Geological) — The relative movement of the two sides of a fault, measured in any chosen direction; also, the specific amount of such movement. Displacement in an apparently lateral direction includes strike-slip and strike separation; displacement in an apparently vertical direction includes dip-slip and dip separation. (AGI, 1972)

Displacement (Engineering) — The geometrical relation between the position of a moving object at any time and its original position. (Webster)

Epicenter — That point on the Earth's surface which is directly above the focus of an earthquake. (AGI, 1972)

Fault — A surface or zone of rock fracture along which there has been displacement, from a few centimeters to a few kilometers in scale. (AGI, 1972)

Fault Surface — In a fault, the surface along which displacement has occurred. (AGI, 1972)

Fault System — Two or more interconnecting fault sets. (AGI, 1972)

Fault Zone — A fault zone is expressed as a zone of numerous small fractures or by breccia or fault gouge. A fault zone may be as wide as hundreds of meters. (AGI, 1972)

Focus (Seism) — That point within the Earth which is the center of an earthquake and the origin of its elastic waves. Syn: hypocenter; seismic focus; centrum (see Introduction). (AGI, 1972)

Ground Response — A general term referring to the response of earth materials to the passage of earthquake vibration. It may be expressed in general terms (maximum acceleration, dominant period, etc.), or as a ground-motion spectrum.

Hypocenter — See focus.

Intensity (earthquake) — A measure of the effects of an earthquake at a particular place on humans and/or structures. The intensity at a point depends not only upon the strength of the earthquake, or the earthquake magnitude, but also upon the distance from the point to the epicenter and the local geology at the point. (AGI, 1972)

Isoseismal line — A line connecting points on the Earth's surface at which earthquake intensity is the same. It is usually a closed curve around the epicenter. Syn: isoseism; isoseismic line; isoseismal. (AGI, 1972)

Liquefaction — A sudden large decrease in the shearing resistance of a cohesionless soil, caused by a collapse of the structure by shock or strain, and associated with a sudden but temporary increase of the pore fluid pressure. (AGI, 1972)

Macroseismic data — Used herein to describe instrumentally recorded earthquakes generally in the range of Richter magnitude 3.0 or more. (This use differs from the AGI definition of "macroseismic observations").

Magnitude (earthquake) — A measure of the strength of an earthquake or the strain energy released by it, as determined by seismographic observations. As defined by Richter, it is the logarithm, to the base 10, of the amplitude in microns of the largest trade deflection that would be observed on a standard torsion seismograph (static magnification = 2800; period = 018 sec; damping constant = 0.8) at a distance of 100 kilometers from the epicenter. (AGI, 1972)

Microseismic data — Used herein to describe instrumentally recorded earthquakes generally in the range of Richter magnitude 3.0 or less. (This use is consistent with the AGI definition of microseism and microseismometer, but is more restricted than their definition of microseismic data).

Natural period — The period at which maximum response of a system occurs. The inverse of resonant frequency.

Normal fault — A fault in which the hanging wall appears to have moved downward relative to the footwall. The angle of the fault is usually 45-90 degrees. This is dip-separation, but there may or may not be dip-slip. (AGI, 1972)

Predominant period — The period of the acceleration, velocity or displacement which predominates in a complex vibratory motion. In the analysis of earthquake vibrations, predominant period is normally the period of the maximum amplitude of the acceleration spectrum.

Response spectrum — An array of the response characteristics of a structure or structures ordered according to period or frequency. The structures are normally single-degree-of-freedom oscillators, and the characteristics may be displacement, velocity or acceleration (see Introduction).

Seiche — All standing waves on any body of water whose period is determined by resonant characteristics of the containing basin as controlled by its physical dimensions. (U.S. Geol. Survey Prof. Paper 544-E)

Seismic seiche — Standing waves set up on rivers, reservoirs, ponds and lakes at the time of passage of seismic waves from an earthquake. (U.S. Geol. Survey Prof. Paper 544-E)

Shear — A strain resulting from stresses that cause or tend to cause contiguous parts of a body to slide relatively to each other in a direction parallel to their plane of contact; specifically, the ratio of the relative displacement of these parts to the distance between them. (AGI, 1972)

Shear wave or S-wave — That type of seismic body wave which is propagated by a shearing motion of material so that there is oscillation perpendicular to the direction of propagation. It does not travel through liquids. (AGI, 1972)

Slip — On a fault, the actual relative displacement along the fault plane of two formerly adjacent points on either side of the fault. Slip is three dimensional, whereas separation is two dimensional. (AGI, 1972)

Strike-slip fault — A fault, the actual movement of which is parallel to the strike (trend) of the fault. (AGI, 1972)

Subsidence — A local mass movement that involves principally the gradual downward settling or sinking of the solid Earth's surface with little or no horizontal motion and that does not occur along a free surface (not the result of a landslide or failure of a slope. (AGI, 1972)

Tectonic — Of or pertaining to the forces involved in, or the resulting structures or features of the upper part of the Earth's crust. (mod. from AGI, 1972)

Tsunami — A gravitational sea wave produced by any large-scale, short-duration disturbance of the ocean floor, principally by a shallow submarine earthquake, but also by submarine earth movement, subsidence, or volcanic eruption, characterized by great speed of propagation (up to 950 km/hr.), long wavelength (up to 200 km.), long period (5 min. to a few hours, generally 10 - 60 min.), and low observable amplitude on the open sea, although it may pile up to great heights (30 m. or more) and cause considerable damage on entering shallow water along an exposed coast, often thousands of kilometers from the source. (AGI, 1972)

Unconsolidated material — A sediment that is loosely arranged or unstratified or whose particles are not cemented together, occurring either at the surface or at depth. (AGI, 1972)

Water table — The surface between the zone of saturation and the zone of aeration; that surface of a body of unconfined groundwater at which the pressure is equal to that of the atmosphere. (AGI, 1972)

APPENDIX D

Seismic Safety Element Guidelines

1. AUTHORITY

A. Authority

Government Code Section 65302(f) requires a Seismic Safety element of all city and county general plans, as follows:

> A Seismic Safety Element consisting of an identification and appraisal of seismic hazards such as susceptibility to surface ruptures from faulting, to ground shaking, to ground failures, or to the effects of seismically induced waves such as tsunamis and seiches.
>
> The Seismic Safety Element shall also include an appraisal of mudslides, landslides, and slope stability as necessary geologic hazards that must be considered simultaneously with other hazards such as possible surface ruptures from faulting, ground shaking, ground failure and seismically induced waves.

The effect of this section is to require cities and counties to take seismic hazards into account in their planning programs. All seismic hazards need to be considered, even though only ground and water effects are given as specific examples. The basic objective is to reduce loss of life, injuries, damage to property, and economic and social dislocations resulting from future earthquakes.

B. Background

Earthquake losses in California through the remainder of this century, assuming that additional significant counter-measures are not taken, have recently been estimated at approximately $20 billion (Urban Geology Master Plan, California Division of Mines and Geology). Estimates of potential loss of life for this period range well up into the thousands and most of this loss is preventable.

The most widespread effect of an earthquake is ground shaking. This is also usually (but not always) the greatest cause of damage. Structures of all types, including engineered structures and public utility facilities, if inadequately constructed or designed to withstand the shaking force, may suffer severe damage or collapse. The vast majority of deaths during earthquakes are the result of structural failure due to ground shaking. Most such deaths are preventable, even with present knowledge. New construction can and should be designed and built to withstand probable shaking without collapse. The greatest existing hazard in the State is the

continued use of tens of thousands of older structures incapable of withstanding earthquake forces. Knowledge of earthquake-resistance design and construction has increased greatly in recent years, though much remains to be learned.

A second effect of earthquakes is ground failure in the form of landslides, rock falls, subsidence and other surface and near-surface ground movements. This is often the result of complete loss of strength of water-saturated sub-surface foundation soils ("liquefaction"), such as occurred near the Juvenile Hall in the 1971 San Fernando earthquake, and in the massive Turnagain Arm landslide in Anchorage, during the 1954 Alaska earthquake. Most such hazardous sites can be either avoided or stabilized if adequate geologic and soil investigations are utilized.

Another damaging effect of earthquakes is ground displacement (surface rupture) along faults. Such displacement of the earth's crust may be vertical, horizontal or both and may offset the ground by as much as 30 feet (as in 1857 in Southern California). It is not economically feasible to design and build foundations of structures (dams, buildings, bridges, etc.) to remain intact across such zones. Fault zones subject to displacement are best avoided in construction. In addition to regional investigations necessary to the basic understanding of faults and their histories, detailed site investigations are needed prior to the approval of construction in any suspected active fault zone. Utilities, roads, canals and other linear futures are particularly vulnerable to damage as the result of ground displacement.

Other damaging effects of earthquakes include tsunamis (seismic sea waves, often called "tidal waves"), such as the one which struck Crescent City and other coastal areas in 1964; and seiches (waves in lakes and reservoirs due to tilting or displacement of the bottom or margin). The failure of dams due to shaking, fault displacement or overtopping (from seiches or massive landsliding into the reservoir) can be particularly disastrous. Most modern dams are designed and constructed to be earthquake-resistant; some older dams are not. In addition to man-made dams, temporary dams may be created by earthquake-triggered landslides. Such inadvertently created dams are certain to fail within a relatively short time.

2. THE SCOPE AND NATURE OF THE SEISMIC SAFETY ELEMENT

A. A general policy statement that:

1. Recognizes seismic hazards and their possible effect on the community.
2. Identifies general goals for reducing seismic risk.
3. Specifies the level or nature of acceptable risk to life and property (see safety element guidelines for the concept of "acceptable risk").
4. Specifies seismic safety objectives for land use.
5. Specifies objectives for reducing seismic hazard as related to existing and new structures.

B. Identification, delineation and evaluation of natural seismic hazards.

C. Consideration of existing structural hazards.

Generally, existing substandard structures of all kinds (including substandard dams and public utility facilities) pose the greatest hazard to a community.

D. Evaluation of disaster planning program

For near-term earthquakes, the most immediately useful thing that a community can do is to plan and prepare to respond to and recover from an earthquake as quickly and effectively as possible, given the existing condition of the area. The seismic safety element can provide guidance in disaster planning.

E. Determination of specific land use standards related to level of hazard and risk.

3. METHODOLOGY

As an initial step, it may be helpful to determine what aspects of the element need greater emphasis. If a community is largely developed, emphasis on structural hazards and disaster planning would be most appropriate. This would also be the case for communities whose greatest hazard will be from ground shaking. On the other hand, communities with extensive open areas and areas subject to urbanization may wish to focus on natural seismic hazards and the formulation of land use policies and development regulations to insure that new development is not hazardous.

Additionally, local planning agencies may wish to consider the preparation of the element or portions of the element in joint action. This would be particularly practical for the study of natural seismic hazards.

A. Initial organization

1. Focus on formulating and adopting interim policy based on very general evaluation of earth science information readily available.
2. Evaluate adequacy of existing information in relation to the identified range and severity of problems.
3. Define specific nature and magnitude of work program needed to complete the element in a second stage.

B. Identification of natural seismic hazards

1. General structural geology and geologic history.
2. Location of all active or potentially active faults, with evaluation regarding past displacement and probability of future movement.
3. Evaluation of slope stability, soils subject to liquefaction and differential subsidence.
4. Assessment of potential for the occurrence and severity of damaging ground shaking and amplifying effects of unconsolidated materials.
5. Identification of areas subject to seiches and tsunamis.
6. Maps identifying location of the above characteristics.

C. Identification and evaluation of present land use and circulation patterns should be recognized in the formulation of seismic safety-land use policies.

D. Identification and evaluation of structural hazards relating structural characteristics, type of occupancy and geologic characteristics in order to formulate policies and programs to reduce structural hazard.

E. Formulation of seismic safety policies and recommendations.

F. Formulation of an implementation program.

4. DEFINITION OF TERMS

A. Acceptable risk: The level of risk below which no specific action by local government is deemed necessary, other than making the risk known.

Unacceptable risk: Level of risk above which specific action by government is deemed necessary to protect life and property.

Avoidable risk: Risk not necessary to take because the individual or public goals can be achieved at the same or less total "cost" by other means without taking the risk.

B. Technical Terminology:

Tsunamis: Earthquake-induced ocean waves, commonly referred to as tidal waves.

Seiches: Earthquake-induced waves in lakes or ponds.

Seismic: Pertaining to or caused by earthquake.

Soil Liquefaction: Change of water saturated cohesionless soil to liquid, usually from intense ground shaking; soil loses all strength.

Tectonic, forms, forces, and movements resulting from deformation of the earth's crust: Movement may be rapid resulting in earthquake, or slow (tectonic creep).

Fault: A plane or surface in earth materials along which failures have occurred and materials on opposite sides have moved relative to one another in response to the accumulation of stress in the rocks.

Active Fault: A fault that has moved in recent geologic time and which is likely to move again in the relatively near future. (For geologic purposes, there are no precise limits to recency of movement or probable future movement that define an "active fault". Definitions for planning purposes extend on the

order of 10,000 years or more back and 100 years or more forward. The exact time limits for planning purposes are usually defined in relation to contemplated uses and structures.)

Inactive Fault: A fault which shows no evidence of movement in recent geologic time and no evidence of potential movement in the relatively near future.

Seismic Hazards: Hazards related to seismic or earthquake activity.

Ground Failures: Include mudslide, landslide, liquefaction, subsidence.

Surface ruptures from faulting: Breaks in the ground surface resulting from fault movement.

5. RELATIONSHIPS

A. To other Elements:

The seismic safety element contributes information on the comparative safety of using lands for various purposes, types of structures, and occupancies. It provides primary policy inputs to the land use, housing, open space, circulation and safety elements.

Because of the close relationship with the safety element the local planning agency may wish to prepare these two elements simultaneously or combine the two elements into a single document. If combined, the required content and policies of each element should be clearly identificable. The local jurisdiction may wish to include the seismic safety element as a part of an environmental resources management element - ERME - as discussed previously.

B. To Environmental Factors:

1. Physical: Geologic hazards can be a prime detrimant of land use capability.

2. Social: May provide basis of evaluating costs of social disruptions, including the possible loss of life due to earthquake and identifies means of mitigating social impact.

3. Economic: Cost and benefits of using or not using various areas related to potential damage or cost of overcoming hazard.

4. Environmental Impact Report: Provides basis for evaluating environmental impact of proposed projects in relation to slope stability, possible structure failure, etc.

C. To Other Agencies:

The State Geologist is required by Chapter 7.5, Division 2 of the Public Resources Code to delineate by December 31, 1973, special studies zones encompassing certain areas of earthquake hazard on maps and to submit such maps to affected cities, counties, and state agencies for review and comments.

By December 31, 1973, the Division of Mines and Geology will have delineated the special studies zones encompassing all potentially and recently active traces of the San Andreas, Calaveras, Hayward, and San Jacinto faults. The special studies zones will be delineated on U.S. Geological Survey quadrangle sheets. The quadrangles listed in Appendix F will be included in the initial distribution which will begin on or about October 1, 1973, and be completed by December 31, 1973. In addition to the faults named above, all active or potentially active faults within the quadrangles listed will be zoned. The zones are ordinarily about one-quarter mile in width.

The State Miniming and Geology Board is required by Chapter 7.5, Division 2 of the Public Resources Code to develop policies and criteria by December 31, 1973, concerning real estate developments or structures to be built within the special studies zones.

IMPLEMENTATION

A. Concurrent or subsequent revision of other general plan elements to give specific recognition to seismic safety policies and criteria.

B. Inclusion of appropriate requirements and procedures in zoning, subdivision and site development regulations and building codes. Designation of special zones with special land development regulations such as "seismic hazards management zones".

C. Preparation of renewal plans for areas where a change in use and development pattern is necessary because of major seismic damage or extreme hazard.

D. Building inspection program to identify unsafe structures and instigate necessary corrective measures.

E. Inclusion of potential earthquake destruction in contingency plans for major disasters and emergencies. Review and liaison with Emergency Preparedness Organizations and Plice Departments of overall plans and major public facilities proposals as to their adequacy in emergency situations.

F. Educational programs to develop community awareness of seismic hazards.

G. Updating the building code to reflect changes in technology.

NOTE: These guidelines drew extensively from:

Suggested Interim Guidelines for the Seismic Safety Element in General Plans, prepared by the Governor's Earthquake Council July, 1972.

Draft Guidelines for the Seismic Safety Element, preapred by Advisory Group on Land Use Planning for Joint Committee on Seismic Safety, California State Legislature, September, 1972.

Seismic Safety Concerns in CIR/OIM Program prepared for CIR by William Spangle & Associates, March 1972, unpublished.

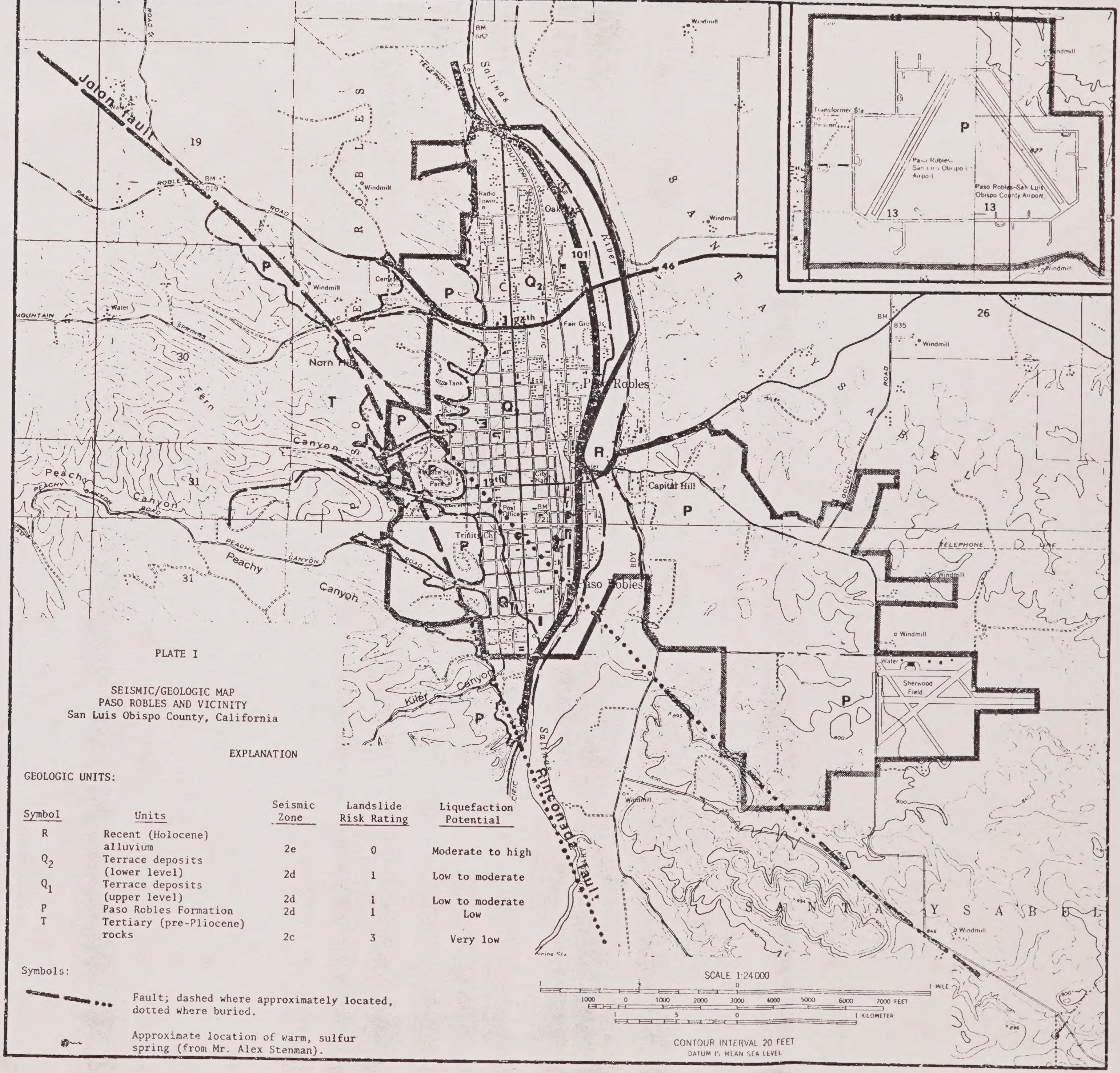

PLATE I

SEISMIC/GEOLOGIC MAP
PASO ROBLES AND VICINITY
San Luis Obispo County, California

EXPLANATION

GEOLOGIC UNITS:

Symbol	Units	Seismic Zone	Landslide Risk Rating	Liquefaction Potential
R	Recent (Holocene) alluvium	2e	0	Moderate to high
Q_2	Terrace deposits (lower level)	2d	1	Low to moderate
Q_1	Terrace deposits (upper level)	2d	1	Low to moderate
P	Paso Robles Formation	2d	1	Low
T	Tertiary (pre-Pliocene) rocks	2c	3	Very low

Symbols:

Fault; dashed where approximately located, dotted where buried.

Approximate location of warm, sulfur spring (from Mr. Alex Stenman).